APPENDIX E

DOSE MODIFICATIONS DUE TO FOOD PREPARATION AND COOKING

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E.1 DOSE MODIFICATIONS OF FISH CONTAMINANT EXPOSURE

Fish preparation and cooking procedures can modify the amount of contaminant ingested by fish consumers. Consequently, exposure and dose are modified. Incorporating a dose modification factor to account for preparation and cooking into the exposure equation requires two types of information:

- Methods used by fish consumers to prepare (trim, skin) and cook (broil, bake, barbeque, fry, smoke) their catch.

- The extent to which a particular contaminant concentration is likely to be decreased by these culinary methods.

To adjust contaminant concentrations appropriately, the modification factors must be matched to the type of sample from which the fish contaminant concentration was measured. For example, it would be inappropriate to apply a modification factor for removing skin if the fish concentrations were based on the analysis of a skin-off fillet. To select the correct approach for evaluating exposure, information on both the distribution of chemicals in fish tissue and alterations due to food preparation and cooking must be used. The modified contaminant concentration is used to modify the exposure estimates used in the risk equations. This information is also useful in development of fish advisories and risk communication activities.

E.1.1 Contaminant Distribution in Fish Tissues

Chemical contaminants are not distributed uniformly in fish. Fatty tissues, for example, will concentrate organic chemicals more readily than muscle tissue. Muscle tissue and viscera will preferentially concentrate other contaminants. This information has important implications for fish analysis and for fish consumers. Depending on how fish are prepared and what parts are eaten, consumers may have differing exposure levels to chemicals. This section is meant as an overview; States should consult primary research studies for more information. In general, contaminant concentrations differ among

- Fatty tissues, muscle tissue, and internal organs
- Different species of fish

- Different age or size classes of fish
- Type of chemical contaminant present in the fish.

E.1.2 Fish Tissue Types

Lipophilic chemicals accumulate mainly in fatty tissues, including the belly, lateral line, subcutaneous and dorsal fat, and the dark muscle, gills, eyes, brain, and internal organs. Some heavy metals, such as cadmium, concentrate more in the liver and kidneys. Muscle tissue often contains lower organic contaminant concentrations than fatty tissues (Great Lakes Sport Fish Advisory Task Force, 1993) but contains more mercury, which binds to proteins (Minnesota Department of Health, 1992).

Many people remove the internal organs before cooking fish and trim off fat before eating, thus decreasing exposure to lipophilic and other contaminants. Removing the fat, however, will not decrease exposure to other contaminants, such as mercury, that are concentrated in muscle and other protein-rich tissues (Gutenmann and Lisk, 1991; Minnesota Department of Health, 1992). Concentrations of mercury have been shown to be higher per gram of fillet in skin-off than in skin-on fillets contaminated with mercury (Dellinger, 1996). Certain subpopulations, including some Asian and Native American groups, eat parts of the fish other than the fillet and may consume the whole fish. Recipes from many cultures employ whole fish for making soups. As a result, more of the fish contaminants are consumed.

States should take preparation methods of local fisher populations into account when assessing exposure levels.

E.1.3 Fish Species

Fish accumulate contaminants from the water column, from suspended sediment and organic matter in the water, and from their food. Depending on their propensity to bioaccumulate contaminants (largely a function of their feeding habits, ability to metabolize contaminants, and fat content), different fish species living in the same area may contain very different contaminant concentrations. Due to bio-magnification, higher trophic level species are more likely to have higher contaminant concentrations. The tissues of the top predators can contain contaminant levels exceeding those in ambient water or sediments by several orders of magnitude.

Where a fish feeds in the waterbody also determines its relative bioaccumulation potential. Bottom feeders, such as carp or catfish, are exposed to more sediments than are fish that feed in the water column. Bottom feeders, therefore, have a tendency to accumulate more of the dense, hydrophobic contaminants, such as chlordane or polychlorinated biphenyls (PCBs), that are adsorbed to the sediment particles. In addition, fish species vary widely in their fat content. Fish low in fat, such as bass, sunfish, crappies, yellow perch, and walleyes, are less likely to accumulate lipophilic toxicants than fattier fish such as bluefish, rainbow trout, lake trout, some salmon, catfish, and carp. Aquatic organisms also differ in their abilities to metabolize and excrete contaminants. For example, one study found fish more able to metabolize benzo[*a*]pyrene than shrimp, amphipod crustaceans, and clams, respectively (U.S. EPA, 1995a). The ability to break down and excrete contaminants may also differ among fish species.

This differential accumulation of contaminants produces very different exposure levels for individuals eating different species of fish. An individual who eats primarily fatty fish species will be more highly exposed to organics than an individual who eats primarily leaner fish species. Thus, States should consider multiple species exposure in their decision to issue fish consumption advisories.

E.1.4 Fish Size or Age Class

Larger size classes of fish within the same species generally contain higher concentrations of bioaccumulative contaminants, especially the more persistent chemicals such as mercury, DDT, PCBs, and toxaphene (U.S. EPA, 1995a). Because larger fish are older, they have had more time to accumulate chemicals from their food and they are more likely to catch larger prey, which themselves have had a longer time to bioaccumulate chemicals (Minnesota Department of Health, 1992). Older fish also concentrate more contaminants in their muscle tissues, which are fattier than muscle tissue in younger fish, particularly along the backbone and lateral lines (Kleeman et al., 1986a). States may choose to issue size-specific consumption advisories and/or explain this correlation in public education efforts.

E.1.5 Chemical Contaminants

Many of the target chemicals examined in this guidance series are lipophilic and accumulate in the fatty tissues. Some contaminants (and their congeners) bioaccumulate in fish more readily than others or are more resistant to metabolism and excretion (Stern et al., 1992). Thus, fish exposed to similar concentrations of different contaminants may accumulate differing levels of contaminants in their tissues.

E.1.5.1 Heavy Metals—

Several studies indicate that mercury, cadmium, and selenium bind to different tissues in fish than do organochlorines. Mercury, for example, binds strongly to proteins, thereby concentrating in muscle tissues of fish (Gutenmann and Lisk, 1991; Minnesota Department of Health, 1992). Mercury also concentrates in the liver and kidneys, though at generally lower rates (Harrison and Klaverkamp, 1990; Marcovecchio et al., 1988). Thus, trimming and gutting can actually result in a greater average concentration of mercury in the remaining tissues compared with the concentration in the whole untrimmed fish. Cadmium concentrates largely in the liver, followed by the kidneys and gills, and less so in the muscle tissue (Harrison and Klaverkamp, 1990; Jaffar and Ashraf, 1988; Marcovecchio et al., 1988; Norey et al., 1990), indicating that cadmium concentrations could be decreased by trimming and gutting fish before consumption. Selenium was shown to concentrate in both the liver and muscle tissues at similar rates (Harrison and Klaverkamp, 1990). Although all three heavy metals are bioaccumulative, cadmium and mercury were found to bioaccumulate at higher rates in some species than in others (Jaffar and Ashraf, 1988).

E.1.5.2 Organochlorines—

Organochlorine pesticides and PCBs tend to concentrate in fatty tissues (Branson et al., 1985; Kleeman et al., 1986a, 1986b; Ryan et al., 1983; U.S. EPA, 1995a). One study positively correlated PCB and mirex levels with fat levels across 10 freshwater fish species (Ryan et al., 1983). These compounds are neither readily metabolized nor excreted and thus tend to bioaccumulate through the food web (U.S. EPA, 1995a). As fish species store fat differently, so will they concentrate organochlorines differently.

PCB levels have been studied in several species and tissues of fish. Adult rainbow trout were found to store PCBs in the carcass and in skeletal muscle, while adult and juvenile yellow perch stored PCBs in the viscera and carcass (Kleeman et al., 1986b). Higher chlorinated biphenyls have been found to bioaccumulate more readily than lower chlorinated biphenyls (Bruggeman et al., 1984; U.S. EPA, 1995a). Unfortunately, some of these higher chlorinated biphenyls tend to be the more potent toxicants as well (Williams et al., 1992).

E.1.5.3 Other Contaminants—

The other chemicals examined in this exposure assessment (organophosphate pesticides and oxyfluorfen) have also been found to bioaccumulate in fish, but no information was found as to how they accumulate differentially in fish tissues. Organophosphates as a group have similar chemical characteristics although they are less persistent in the environment than the organochlorines (U.S. EPA, 1995a).

States may wish to use this chemical-specific information on distribution in fish tissues to assess whether a local population may be exposed unreasonably to a given contaminant, due to particular eating habits such as eating only one species of fish, eating specific parts of the fish, or eating only fat or lean fish species.

E.2 ESTIMATING DOSE MODIFICATION BASED ON PREPARATION METHODS

This section presents data on the effects of various preparation methods on contaminant concentrations in fish tissue. In the absence of specific data on fish preparation methods, the U.S. Environmental Protection Agency (EPA) recommends using fillets as the standard sample for analyzing chemical contaminants. Readers are referred to Volume 1, 2nd edition, of this series for a more complete discussion of this analysis (U.S. EPA, 1995a). The fillet should consist of the portion of the individual organism commonly consumed by the general U.S. population or a specific subpopulation of concern. EPA recommends analyzing skin-on fillets (including the belly flap) for most scaled finfish. Conversely, skin-off fillets may be more appropriate for target species without scales (e.g., catfish). State or local agencies, however, are advised to select the sample type most appropriate for each target species based on consumption patterns of local populations and should sample the whole body of the fish if a local subpopulation typically consumes whole fish. Following these guidelines, States may have concentration data from samples with skin-on or from whole fish. In food preparation, fish may be further trimmed and have additional fat removed.

When States have data on the preparation methods of the target fish consuming populations, appropriate modification factors from these studies can be used to adjust assumed fish chemical contaminant concentrations. Without food preparation data, however, States should not assume that specific methods are employed, since fish preparation and cooking techniques frequently vary among individuals and often depend on the type of fish consumed. As noted earlier, many groups known to consume large quantities of fish, including Native American and Asian American fishers, often consume most of the fish and may do very little trimming. Consequently, assuming a loss of toxic chemicals may lead to an underestimate of exposure and risk for these groups.

EPA does not recommend the use of dose modification factors for setting health-based intake limits unless data on local methods of preparation and their impact on contaminant concentrations are available.

EPA does, however, recommend that all fish advisories emphasize the importance of skinning, trimming (including gutting), and certain ways of cooking as effective means to minimize the risks from chemical contaminants. To achieve the best results, all three techniques should be used together. States are encouraged to include illustrations in their fish advisories showing the location of fatty tissue in fish and describing the parts of the fish tissue to be trimmed. This type of information could be provided to fish consumers as part of a fish advisory program through risk communication efforts. Further information on risk communication is included in Volume 4 in this series of guidance documents (U.S. EPA, 1995b).

The degree of preparation-related reduction in contaminant concentration depends on the

- fish species and size (age class)
- chemical contaminant
- specific food preparation and cooking techniques used.

The results of a number of fish preparation and cooking studies are presented in Tables E-1 and E-2. The data are relevant primarily to concentrations in the standard fillet. Dose modification will depend on how the dose is determined

Table E-1. Summary of Contaminant Reductions Due to Skinning, Trimming, and Cooking (Based on Standard Fillet)

Species	Contaminant	Activity[a]	Reduction (%)[b]	Reference
Brown Trout	DDE	Trimming	52	Skea et al. (1979)
	DDE	Smoking	27	Skea et al. (1979)
	DDE	Broiling	20	Skea et al. (1979)
	Mirex	Trimming	44	Voiland et al. (1991)
	Mirex	Trimming	45	Skea et al. (1979)
	Mirex	Smoking	39	Skea et al. (1979)
	Mirex	Broiling	26	Skea et al. (1979)
	Mirex	Trimming & cooking	74	Skea et al. (1979)
	PCB	Trimming	46	Voiland et al. (1991)
	PCB	Trimming	43	Skea et al. (1979)
	PCB	Smoking	27	Skea et al. (1979)
	PCB	Broiling	0	Skea et al. (1979)
	PCB	Trimming & cooking	78	Skea et al. (1979)
Carp	α-Chlordane	Skin-off & deep frying	44	Zabik et al. (1993)
	α-Chlordane	Skin-off & pan frying	17	Zabik et al. (1993)
	α-Chlordane	Skin-on & deep frying	38	Zabik et al. (1993)
	α-Chlordane	Skin-on & pan frying	51	Zabik et al. (1993)
	Dieldrin	Skin-off & deep frying	76	Zabik et al. (1993)
	Dieldrin	Skin-off & pan frying	58	Zabik et al. (1993)
	Dieldrin	Skin-on & deep frying	56	Zabik et al. (1993)
	Dieldrin	Skin-on & pan frying	59	Zabik et al. (1993)
	Heptachlor epoxide	Skin-on & pan frying	82	Zabik et al. (1993)
	PCB	Skin-off & deep frying	37	Zabik et al. (1993)
	PCB	Skin off & pan frying	25	Zabik et al. (1993)
	PCB	Skin-on & deep frying	38	Zabik et al. (1993)
	PCB	Skin-on & pan frying	31	Zabik et al. (1993)
Chinook Salmon	α-Chlordane	Skin-off & baking	44	Zabik et al. (1993)
	α-Chlordane	Skin-off & charbroiling	41	Zabik et al. (1993)
	α-Chlordane	Skin-off & charbroiling after scoring	45	Zabik et al. (1993)
	α-Chlordane	Skin-off & canning	37	Zabik et al. (1993)
	α-Chlordane	Skin-on & baking	27	Zabik et al. (1993)
	α-Chlordane	Skin-on & charbroiling	42	Zabik et al. (1993)
	α-Chlordane	Skin-on & charbroiling after scoring	51	Zabik et al. (1993)
	Dieldrin	Skin-off & baking	30	Zabik et al. (1993)
	Dieldrin	Skin-off & charbroiling	31	Zabik et al. (1993)
	Dieldrin	Skin-off & charbroiling after scoring	40	Zabik et al. (1993)
	Dieldrin	Skin-off & canning	40	Zabik et al. (1993)
	Dieldrin	Skin-on & baking	29	Zabik et al. (1993)
	Dieldrin	Skin-on & charbroiling	40	Zabik et al. (1993)
	Dieldrin	Skin-on & charbroiling after scoring	50	Zabik et al. (1993)

See footnotes at end of table. (continued)

Table E-1. (continued)

Species	Contaminant	Activity[a]	Reduction (%)[b]	Reference
Chinook Salmon (con.)	Heptachlor epoxide	Skin-off & baking	52	Zabik et al. (1993)
	Heptachlor epoxide	Skin-off & charbroiling	40	Zabik et al. (1993)
	Heptachlor epoxide	Skin-off & charbroiling after scoring	42	Zabik et al. (1993)
	Heptachlor epoxide	Skin-off & canning	37	Zabik et al. (1993)
	Heptachlor epoxide	Skin-on & baking	23	Zabik et al. (1993)
	Heptachlor epoxide	Skin-on & charbroiling	45	Zabik et al. (1993)
	Heptachlor epoxide	Skin-on & charbroiling after scoring	48	Zabik et al. (1993)
	PCB	Skin-off & baking	38	Zabik et al. (1993)
	PCB	Skin-off & charbroiling	44	Zabik et al. (1993)
	PCB	Skin-off & charbroiling after scoring	46	Zabik et al. (1993)
	PCB	Skin-off & canning	36	Zabik et al. (1993)
	PCB	Skin-on & baking	33	Zabik et al. (1993)
	PCB	Skin-on & charbroiling	40	Zabik et al. (1993)
	PCB	Skin-on & charbroiling after scoring	49	Zabik et al. (1993)
	Toxaphene	Skin-off & baking	34	Zabik et al. (1993)
	Toxaphene	Skin-off & charbroiling	30	Zabik et al. (1993)
	Toxaphene	Skin-off & charbroiling after scoring	34	Zabik et al. (1993)
	Toxaphene	Skin-off & canning	74	Zabik et al. (1993)
	Toxaphene	Skin-on & baking	22	Zabik et al. (1993)
	Toxaphene	Skin-on & charbroiling	37	Zabik et al. (1993)
	Toxaphene	Skin-on & charbroiling after scoring	47	Zabik et al. (1993)
Lake Trout	α-Chlordane	Skin-off & baking	26	Zabik et al. (1993)
	α-Chlordane	Skin-off & charbroiling	41	Zabik et al. (1993)
	α-Chlordane	Skin-off & salt boiling	6	Zabik et al. (1993)
	α-Chlordane	Skin-on & smoking	53	Zabik et al. (1993)
	DDT	Skin-off & baking	14	Zabik et al. (1993)
	DDT	Skin-off & charbroiling	21	Zabik et al. (1993)
	DDT	Skin-off & salt boiling	1	Zabik et al. (1993)
	DDT	Skin-on & smoking	60	Zabik et al. (1993)
	Dieldrin	Skin-off & baking	8	Zabik et al. (1993)
	Dieldrin	Skin-off & charbroiling	15	Zabik et al. (1993)
	Dieldrin	Skin-off & salt boiling	16	Zabik et al. (1993)
	Dieldrin	Skin-on & smoking	43	Zabik et al. (1993)
	Heptachlor epoxide	Skin-off & baking	39	Zabik et al. (1993)
	Heptachlor epoxide	Skin-off & charbroiling	39	Zabik et al. (1993)
	Heptachlor epoxide	Skin-off & salt boiling	3	Zabik et al. (1993)
	Heptachlor epoxide	Skin-on & smoking	59	Zabik et al. (1993)
	PCB	Skin-off & baking	13	Zabik et al. (1993)
	PCB	Skin-off & charbroiling	29	Zabik et al. (1993)
	PCB	Skin-off & salt boiling	10	Zabik et al. (1993)

See footnotes at end of table. (continued)

Table E-1. (continued)

Species	Contaminant	Activity[a]	Reduction (%)[b]	Reference
Lake Trout (con.)	PCB	Skin-on & smoking	46	Zabik et al. (1993)
	Toxaphene	Skin-off & baking	31	Zabik et al. (1993)
	Toxaphene	Skin-off & charbroiling	40	Zabik et al. (1993)
	Toxaphene	Skin-off & salt boiling	5	Zabik et al. (1993)
	Toxaphene	Skin-on & smoking	51	Zabik et al. (1993)
Smallmouth Bass	DDE	Trimming	54	Skea et al. (1979)
	DDE	Baking	16	Skea et al. (1979)
	DDE	Frying	75	Skea et al. (1979)
	Mirex	Trimming	64	Skea et al. (1979)
	Mirex	Baking	21	Skea et al. (1979)
	Mirex	Frying	75	Skea et al. (1979)
	Mirex	Trimming & cooking	80	Skea et al. (1979)
	PCB	Trimming	64	Skea et al. (1979)
	PCB	Baking	16	Skea et al. (1979)
	PCB	Frying	74	Skea et al. (1979)
	PCB	Trimming & cooking	80	Skea et al. (1979)
Walleye	DDT	Skin-on & baking	4	Zabik et al. (1993)
	DDT	Skin-on & charbroiling	16	Zabik et al. (1993)
	DDT	Skin-on & deep frying	11	Zabik et al. (1993)
	α-Chlordane	Skin-on & baking	32	Zabik et al. (1993)
	α-Chlordane	Skin-on & charbroiling	33	Zabik et al. (1993)
	α-Chlordane	Skin-on & deep frying	-25	Zabik et al. (1993)
	Dieldrin	Skin-on & baking	3	Zabik et al. (1993)
	Dieldrin	Skin-on & charbroiling	3	Zabik et al. (1993)
	Dieldrin	Skin-on & deep frying	26	Zabik et al. (1993)
	PCB	Skin-on & baking	17	Zabik et al. (1993)
	PCB	Skin-on & charbroiling	24	Zabik et al. (1993)
	PCB	Skin-on & deep frying	14	Zabik et al. (1993)
	Toxaphene	Skin-on & baking	45	Zabik et al. (1993)
	Toxaphene	Skin-on & charbroiling	43	Zabik et al. (1993)

[a] Skin-on refers to the trimming of only the belly flap; skin-off refers to the removal of the belly flap as well as the lateral line and associated fat tissue.
[b] Data from the Zabik (1993) study were condensed by averaging contaminant reductions across lakes whenever a fish species was sampled from more than one of the Great Lakes.

Table E-2. Summary of Contaminant Reductions Due to Skinning, Trimming, and Cooking (Based on Standard Fillet, Whole Fish or Other Fillet)

Species	Contaminant	Activity	Reduction (%)[a]	Reference
American Shad	DDT/DDE	Trimming	40	NYSDEC (1981)
	PCB	Trimming	44	NYSDEC (1981)
Bluefish	PCB	Trimming	59	Armbruster et al. (1989)[c]
	PCB	Baking	8	Armbruster et al. (1989)[c]
	PCB	Broiling	8	Armbruster et al. (1989)[c]
	PCB	Frying	8	Armbruster et al. (1989)[c]
	PCB	Poaching	8	Armbruster et al. (1989)[c]
	PCB	Trimming & cooking	67	Armbruster et al. (1989)[c]
Chinook Salmon	Mirex	Trimming	15	NYSDEC (1981)
	PCB	Trimming	25	NYSDEC (1981)
	PCB (1248)	Trimming & baking	15	Smith et al. (1973)
	PCB (1248)	Trimming & poaching	-1	Smith et al. (1973)
	PCB (1254)	Trimming and baking	-1	Smith et al. (1973)
	PCB (1254)	Trimming & poaching	2	Smith et al. (1973)
Coho Salmon	DDT	Trimming	62	Reinert et al. (1972)
	DDT/DDE	Trimming	53	NYSDEC (1981)
	DDT	Dressing	0	Reinert et al. (1972)
	Mirex	Trimming	21	NYSDEC (1981)
	PCB	Trimming	32	NYSDEC (1981)
	PCB (1248)	Trimming & baking	4	Smith et al. (1973)
	PCB (1248)	Trimming & poaching	-9	Smith et al. (1973)
	PCB (1254)	Trimming & baking	-10	Smith et al. (1973)
	PCB(1254)	Trimming & poaching	-14	Smith et al. (1973)
	Dieldrin	Roasted	25	Zabik et al. (1993)
	Dieldrin	Microwave	47	Zabik et al. (1993)
Lake Trout	DDT	Trimming	54	Reinert et al. (1972)
	DDT/DDE	Trimming	46	NYSDEC (1981)
	DDT	Dressing	0	Reinert et al. (1972)
	DDT	Frying	64-72	Reinert et al. (1972)
	DDT	Broiling	64-72	Reinert et al. (1972)
	DDT	Broiling	39	Zabik et al. (1993)
	DDT	Roasted	30	Zabik et al. (1993)
	DDT	Microwave	54	Zabik et al. (1993)
	Dieldrin	Broiling	48	Zabik et al. (1993)
	Mirex	Trimming	50	NYSDEC (1981)
	PCB	Trimming	50	NYSDEC (1981)
Perch	DDT	Dressing	90	Reinert et al. (1972)
Winter Flounder (Seafish)	PCB	Deep frying	47	EPA (1992)
	PCB	Pan frying	-15	EPA (1992)
	PCB	Broiling	-17	EPA (1992)

[a] It could not be positively determined that reduction figures were calculated as changes in contaminant concentrations from the standard fillet.

[b] Average of findings reported in New York State Department of Environmental Conservation (1981) and White et al. (1985).

[c] Averages of findings reported in Armbruster et al. (1989).

initially (i.e., what portion of the fish was analyzed to determine contamination concentrations). Note that contaminants distributed throughout the fish muscle tissue, such as mercury, will not be substantially reduced through most fish preparation methods.

Table E-1 summarizes various study results where specific activities reduce contaminants in standard fillets of fish species. Study citations are provided for readers who wish to obtain more information on study methods and results. Similar information obtained from studies of standard fillet, whole fish, or other fillet types is presented in Table E-2. Both tables show that a high level of variability should be expected in the effectiveness of skinning, trimming, and cooking fish. The average reductions are reported for each study. Although significant variability in percent reductions was found within each study, the mean reduction data suggest that significant reductions can occur with food preparation and cooking (Voiland et al., 1991). The cooked weight of fish tissue is always less than the uncooked weight. On average, cooking reduces the fish weight by about one-third (Great Lakes Sport Fish Advisory Task Force, 1993); therefore, the standard meal of 1/2 pound of raw fillet weighs about 1/3 pound after cooking. Most of the weight reduction is due to water loss, but fat liquefication and volatilization also contribute to weight reduction (Great Lakes Sport Fish Advisory Task Force, 1993). The actual weight loss depends on the cooking technique used.

The results of studies shown in Tables E-1 through E-3 do not address chemical degradation due to heat applied in cooking. Zabik et al. (1993) found that smoking

Table E-3. Average Contaminant Reductions Due to Cooking in Great Lakes Fish [a]

Chemical Contaminant	Reduction (%)
p,p'-DDT	34.0
p,p'-DDE	29.4
p,p'-DDD	29.0
α-Chlordane	34.8
γ-Chlordane	33.0
Oxychlordane	35.6
cis-Nonachlor	35.7
trans-Nonachlor	27.9
Dieldrin	28.7
Heptachlor epoxide	35.6
Toxaphene	36.5
Total PCBs	30.3

[a] Processing involved trimming the belly flap area for skin-on fillets and skinning and removing fatty tissue from the belly flap area and the lateral line for skin-off fillets.

Source: Zabik et al. (1993).

lake trout reduced pesticides and total PCBs significantly more than other cooking methods, but resulted in the formation of low levels of PAHs. Until there is more information about the toxicity of the byproducts generated during the degradation of PCBs or the other chemicals of concern, EPA recommends that no dose modification be assumed due to degradation alone.

Zabik et al. (1993) found similarities in the percentage of pesticide and total PCB reductions (ranging from 27.9 to 36.5 percent) attributed to cooking for Great Lakes carp, salmon, lake trout, walleye, and white bass analyzed (Table E-3). However, they assessed only lipophilic chlorinated hydrocarbons. Similarities in their chemical behavior may be responsible for the similarities observed in the study results listed in Table E-3. The information provided in this table is not species-specific, which may limit the situations to which it is applicable.

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